MILK POWDER PRODUCTION

WATSON DairyConsulting

Milk Powder Production - Milk Powder Producers - Milk Powder Specification

Calculator for milk fat % to give desired fat % in Milk Powder
Milk Powder Production Cost estimation calaculator
Whole Milk Powder Specification
Skimmed Milk Powder Specification (Medium Heat)
Whey Powder Specification

Milk Powders Manufacturing - Milk Powder Production process description
The Spray Drying milk powder production process begins with liquid milk (skim milk powder, whole milk powder, fat filled milk powder, buttermilk powder, whey powder, cream powder, cheese powder, demineralised whey powder, whey protein concentrate)

Milk Powder Production
Raw milk on arrival at the factory is rapid tested for temperature, hygiene, antibiotics, water addition and adulteration.
On acceptance the milk is pumped into a silo storage tank at the processing plant and held at temperatures below 7 C and usually below 5 C.
Raw whole milk has varying Fat & Solids Not Fat (SNF) content and typically between 3.5% and 4.5% Fat and 8% to 9% SNF giving typical Total Solids of 12.5%. Developing countries are milk solids usually lower and care should be taken in ensuring that costs / yields are calculated accurately for any planned high volume dairy manufacturing plant and we suggest you prepare a very detailed yield spreadsheet., use the calculator on the link above to view the effect of 0.1% protein or moisture variation on annual milk powder production yield and milk powder profitability.
Milk is mostly collected in insulated tankers from dairy farms or milk collection stations. Prior to collection the driver will carry out quality and measurement tests to ensure the milk is of the required quality.
Adulteration of raw milk in some countries is prolific and a real barrier to globally operating companies establishing facilities due to the high brand risk involved.
When the raw milk arrives at the manufacturing plant it is usually separated into cream and skimmed milk to enable standardization of the fat content prior to spray drying. High volume manufacturers will automate this cream fat standardization using an inline “standomat” which doses cream back into the skim to give the correct fat % in the milk to be processed.
Some high volume plants particularly in the US also standardise the SNF content to maximise yields and give a consistent quality.
The microbial quality of milk powders is very important and it is possible at this early stage of processing to take out 99.9% of the spore-forming bacteria by either bacto-fugation or microfiltration prior to heat treatment.
This is a the ideal next stage but many processors primarily due to cost do not include this stage.
Both processes require that the milk is first separated and then the skimmed milk portion has the bacteria removed and the cream is them high temperature pasteurised and returned to the milk (if required)
This is the method used for ESL milk (Extended Shelf Life). Infant Formula manufactures operating in developing countries should use a bactofuge or microfiltration plant to ensure finished produt quality.
The milk is high temperature short-time pasteurized (HTST) by heating to at least 72 C, and holding at or above this temperature for at least 15 seconds, (An equivalent temperature / time combination can be used). Most high volume liquid milk plants now operate on a higher holding time of 25 to 35 as a precaution over the possible survival of MAP which can cause Crohn’s disease in humans.
(Mycobacterium avium subspecies paratuberculosis may be capable of surviving pasteurization.)
Heat treatment affects the functional properties of skim milk powder and the keeping quality of whole milk powder, so the temperature and time combinations used by manufacturers can vary widely depending on the required properties required of the finished powder.
In skimmed milk powder, the extent of heat treatment (and holding time) can be measured by the whey protein nitrogen index (WPNI), which measures the amount of un-denatured whey protein.
Skimmed milk powder processing differs from whole milk and buttermilk processing by the heat treatment given to skim milk before evaporation.
The skimmed milk heat treatment temperature coupled with the holding time determines the heat classification of the powder produced. For skim milk powder classified as “low-heat”, the milk is low temperature pasteurized with little or no holding required, while heat treatment for a “high-heat” method requires heating milk to 85-88 C and holding at this temperature for 15 to 30 seconds..There is no requirement to homogenize skimmed milk for powder production because of its low fat content. High heat, heat stable powders are also produced by varying the evaporation conditions.
Homogenisation is not a mandatory step in whole milk or buttermilk processing, but is usually applied in order to decrease the free fat content.

Two stage homogenization is usually used as single stage can result in fat globules coalescing into larger globules more readily. This is considered important for infant formula manufacturing. Two stage homogenising is preferable to ensure minimal re-coalescing of globules take place.
Fat globules with damaged protective membranes reduce milk powder solubility and increase the risk of to oxidative rancidity.
Homogenization helps convert free fat into fat globules and membranes are regenerated by protein adsorption on the globule surfaces.
Milk powder heat treatment varies depending on the finished product specification. Infant formula milk powder treatment is higher than most other powders. The aim is to destroy all pathogenic and as many of the other microorganisms present and to inactivate enzymes, particularly lipase, which can cause fat lipolysis during storage resulting in "off odours". This also reduces the risk of oxidative changes during storage.
There are special treatments available from certain evaporator manufacturers that can provide a very good reduction in thermoduric bacteria which tend to grow in evaporators and cause issues with powder quality (High thermophile counts) Counts vary depending on the time of year and type of feed. (usually winter silage feed increases thermophillic spore counts in raw milk) Other optional ingredients such as vegetable fats, vitamins and minerals are added to the milk prior to drying, ensuring appropriate heat treatment
The milk is concentrated in a series of calandrias in an evaporator to around 40-60% total solids, prior to Spray Drying.Most milk evaporators are today of the falling film type where a fine film of milk / concentrate is passed down the tubes wetting the surface whilst steam is on the other side of the tube and the vapours extracted from the centre by vacuum.
Vapours are normally recompressed in a vapour recompressor making evaporators very efficient.
Water from evaporators can be recovered and re used. .
Evaporation of the milk prior to drying is done for reasons of energy efficiency as it is far cheaper to evaporate the water than to spray dry it. The energy used in multi pass evaporators with steam vapour recompression is about 10 times less than spray drying.

Milk Powder Spray Dryer – MILK POWDER SPRAY DRYING – Milk Powder Spray Dryers
Spray drying milk powder involves atomizing concentrated milk (or other liquids) into a hot air stream (180 – 220 C). The atomizer may be either a pressure nozzle or a centrifugal disc. By controlling the size of the droplets, the air temperature, and the airflow, it is possible to evaporate almost all the moisture while exposing the solids to relatively low temperatures. Spray drying yields milk powders with excellent solubility, flavour and colour.
This is the most common procedure for manufacturing milk powders.
The spray drying process is typically a two-stage process that involves the spray dryer at the first stage with a static fluid bed integrated in the base of the drying chamber. The second stage is an external vibrating fluid bed.
Product is moved through the two stage process quickly to prevent overheating of the powder. Powder leaves the dryer and enters a system of cyclones that simultaneously cools it.
Spray dryers can also have bag filters to reduce environmental emissions and also to increase yield and ensure that there are no powder particles emitted to attract birds and rodents and also act as a medium for microbial growth which can then be carried back into the plant.
The technology for air filtration and Spray Dryer drying of inlet air to ensure a standard moisture and temperature is important in high volume high quality end products and ensures a process consistency improving yield (Consistent moisture) and giving a consistent bulk density.
Instantising or Agglomeration of milk powders (more readily solube)
Instantising results in a Spray Dried milk powder with improved reconstitution properties. Instantizing is attained by agglomeration, a process of increasing the amount of air incorporated between powder particles. During reconstitution, the air is replaced by water. Incorporated air enables a larger amount of water to come into contact immediately with the powder particle during reconstitution.
With whole milk powder and buttermilk powder, a small amount of lecithin is typically applied during agglomeration. Lecithin is a natural phospholipid that improves the ability of high-fat products to dissolve in water. Lecithin also occurs in milk fat.
Spray Dried powders with particle size less than about 100 micron typically tend to form lumps when mixed with water and require strong mechanical stirring to become fully dissolved in the liquid. Water, aided by capillary forces, penetrates into the narrow spaces between the particles and the powder begins to dissolve. As it does so, it forms a thick, gel-like mass which resists further penetration of water. Lumps containing dry powder in the middle are formed and, if enough air is locked into these lumps, they will float to the surface of the liquid and resist further dispersion.
To produce a more readily dispersible product, the specific surface of the powder has to be reduced and the liquid needs to penetrate more evenly around the particles. In an agglomerated powder with an open structure, the large passages between the individual powder particles assist in quickly displacing the air and allow liquid to penetrate before an impenetrable gel layer is formed. The powder can disperse into the bulk of the liquid.
Particles agglomerate when they are brought into contact and at least one of them has a sticky surface.
The most common method is spray humidification where the surface of the particle is uniformly wetted by the

application of a fine spray mist and this method is also employed in the Lecithination instantizing and agglomeration process.
Agglomeration is usually carried out in a vibrating fluidized bed where the re-wetting takes place and the particles are forced to collide and stick to each other whilst further gradual drying takes place.
There must be sufficient agitation in the fluid bed to ensure distribution of the spray on the particle surfaces and to prevent lump formation.
Agglomerate characteristics can be adjusted by varying operating parameters such as the fluidizing velocity, spray rate and temperatures.
The system can accept some degree of variation of the feed rate of powder and liquid as the product level in the fluid bed is always constant, controlled by an overflow weir. Thus, the re-wetting section will not be emptied of powder. Even during a complete interruption of powder flow, the fluidized material will remain in the re-wet section as a stabilizing factor in the process.
Fluid bed agglomeration is very consistent due to the stabilizing effect of the powder volume in the re-wet zone.
Agglomeration can be accomplished using only water as a re-wet media. This applies to most dairy products and to maltodextrine-based flavor formulations. For some products, the size and strength has been obtained by using a solution of the material itself as the binder liquid.
In the case of relatively water insoluble materials, a separate binder material can be used, but it must be one that does not compromise the integrity of the final product. The addition of the binder material may have a beneficial effect on the end product at times.

Milk concentrate Atomization
The two principle means of atomization are centrifugal and pressure nozzle – both have their advantages and disadvantages. Centrifugal atomizers generally result in a finer powder particle than pressure nozzle atomizers.

Milk concentrate viscosity
Viscosity is generally maintained below 250 centipoise at the atomizer. The most efficient way to reduce viscosity is to increase the feed temperature. This will also increase the milk powder spray dryer capacity.

Milk Powder Pressure nozzle
A high pressure pump feeds the liquid to nozzles or atomiser and the dryer chamber. Nozzles typically produce a powder with a high bulk density, a narrow particle size distribution and, in the case of fat containing powders a low free-fat content due to the homogenizing effect. The bulk density of the milk powder is mostly affected by the density of the concentrate. A good process control system is essential to ensure a consistent product.

Cone angle
Optimum mixing between the liquid spray and the hot air entering the milk spray drying chamber is achieved by using the widest possible spray angle together with multiple nozzles. The capacity of a spray drying chamber can usually be increased by increasing the number and type of spray nozzles as well as by adjusting air flows and temperatures.

Milk Powder Swirl chamber
Feed liquid enters tangentially into the swirl chamber, the greater the feed pressure the faster the rotational speed and the wider the spray angle.
Swirl chamber sizes affect the angle of spray and there are charts available for selection of nozzles and swirl chambers depending on your powder requirements and chamber design.

Milk powder High Pressure Nozzle Orifice size
The choice of orifice size is dependent on the liquid flow rate and the powder particle size desired.
For finer powder particles, use a higher nozzle pressure.
For larger particles, use a bigger orifice to achieve a lower nozzle pressure / velocity.

Milk powder Production concentrate Flow rate
The flow rate of liquid into the spray dryer is used to control the dryer outlet temperature and the powder moisture.
Reduced solids content of the feed results in wasted energy and reduced powder throughput coupled with high bulk density.

Milk Powder production high pressure nozzle pressure
For larger milk powder particle size use a lower nozzle pressure and for finer milk powder particle size, use a higher atomising nozzle pressure.
Nozzle pressure, for a given orifice size, varies as the square of the flow rate – a higher flow gives a much higher pressure.

Centrifugal atomiser
For a finer powder particles run the wheel at a higher speed and for a coarser particle, use a lower wheel speed. The wheel speed affects the hydraulic capacity of the atomizer, although this is usually only seen at extremely high liquid rates or very low wheel speeds.
A higher wheel speed causes a greater pumping action within the atomizer wheel and contributes to the hydraulic capacity of the atomizer. If the hydraulic capacity of a centrifugal atomizer is exceeded for any reason, feed liquid is forced to flow up the atomizer spindle and through the bearings, causing very rapid failure in most cases.
Inlet temperature
The air inlet temperature to the spray dryer controls the production rate of the final powder. For higher production, you run with a higher inlet temperature. There are three other factors which can limit the inlet temperature:
Powder ignition temperature
Many powders will ignite and burn if they are exposed to temperatures above their ignition temperature. If this occurs in a spray dryer, it can result in a fire and possibly an explosion.

Outlet temperature and powder moisture
The outlet temperature is controlled by adjusting the feed rate and this also controls the powder moisture based upon a consistent temperature of inlet, feed solids content and humidity of inlet air.

Roller or drum drying of milk powders
Roller drying involves direct contact of a layer of concentrated milk with the hot surface of rotating rollers or drums. This method is not used often because of the adverse affects the heat has on milk components. Heat often causes irreversible changes such as lactose carmelization, Maillard reaction and protein denaturation. Roller drying typically results in more scorched powder particles and poorer powder solubility than spray drying.
For crack testing of spray dryer chambers, cyclones please contact us.